REMARKS

The Office Action of August 19, 2005 was received and reviewed. The Examiner is thanked for his review and consideration of this application.

Claims 1-11 were pending prior to the instant amendment. By this amendment, claims 1, 5 and 7 have been amended, and claim 8 has been canceled without prejudice or disclaimer to the subject matter disclosed therein. Accordingly, claims 1-7 and 9-11 are now pending in the application.

The basis for the amended claims may be found throughout the specification, drawings and claims of the original application. The Examiner is respectfully requested to reconsider and withdraw the rejections in view of the amendments and remarks contained herein.

Referring now to the detailed Office Action, the Application Data Sheet is deemed defective because no filing of foreign application was acknowledged. In response, a new application data sheet is submitted as attached herewith to acknowledge the filing of Taiwan Patent Application Serial No. 91124581 entitled "Top Emission Light Emitting Display with Reflective Layer" filed on October 23, 2002 so as to comply with the requirements of 37 CFR 1.63(c).

Claim 5 stands objected to as the dependency of claim 5 is not in numerical order. Accordingly, claim 5 has been amended to depend from claim 4 so as to overcome the claim objection.

Claims 1-6 stand rejected under 35 §U.S.C. §103(a) as being unpatentable over Antoniadis (U.S. Patent No. 6,366,017 – hereafter Antoniadis) in view of Kanou (U.S. Patent Application Publication No. 2004/0070709 – hereafter Kanou). This rejection is respectfully traversed at least for the reasons provided below.

Regarding claim 1, the claim has been amended, as shown above, to further clarify the present invention. Amended claim 1 recites a top emission organic light emitting display (OLED), comprising a substrate; <u>a reflective layer disposed on the substrate; a first electrode</u>

disposed on the reflective layer, a contact surface between the reflective layer and the first electrode being a rough surface so as to reduce color shift with a wide viewing angle; an organic layer disposed on the first electrode; and a transparent second electrode disposed on the organic layer; wherein, as a bias voltage is applied to the top emission OLED via the first electrode and the transparent second electrode, the organic layer emits radiation in multiple directions, the reflective layer reflects the radiation toward the transparent second electrode.

According to Fig. 3 and paragraph [0013] of the specification, the contact surface between the reflective layer 410 and the first electrode 408 is a rough surface to comply with different reflection characteristics of the top emission OLED. That is, the OLED of the present invention is developing with a wide viewing angle by using the rough surface between the reflective layer and the first electrode.

Applicants submit herewith a teaching reference to Mameno et al. (hereafter Mameno) entitled "High-Performance and low-Power AMOLED Using White Emitter with Color-Filter Array". According to Mameno, the rough surface (or dimple interface) can reduce a color shift with a wide viewing angle, as disclosed on lines 8-10 in the Abstract. Also referring to Figs. 6 and 10 of Mameno, one layer is varied in thickness. The thickness variations cause variations in the interference conditions and strong peak wavelength. As a result, the total color emitted is averaged and has no intensified peak.

On the other hand, with respect to Antoniadis, the reference does not disclose OLED with a contact surface between the reflective layer and the first electrode being a rough surface.

With respect to Kanou, the reference discloses a TFT LCD display apparatus includes a glass substrate 53, a transparent electrode 55, a glass substrate 40, a thin film transistor 44 and having a convex/concave structure 45a on its surface, a reflection electrode 48 having a shape reflecting the convex/concave structure 45a and connected to a source electrode of the thin film transistor 44, and a liquid crystal layer 56. In other words, the convex/concave surface (contact surface) is between the reflection electrode 48 and the insulation film 45, not between a reflective layer and a first electrode as the Examiner interpreted.

Furthermore, the reflective layer of Kanou is the reflection electrode 48, and no additional reflective layer is introduced. As shown in Fig. 1 of Kanou, the incident light is reflected by the reflection electrode 48 itself, not the contact surface between the reflective layer and the first electrode as the present invention disclosed. In other words, Kanou implements a reflection electrode with a rough surface directly contacting the liquid crystal layer 56 and reflecting lights, while the presently claimed invention discloses a first electrode with a smooth surface contacting the organic layer and a rough contact surface contacting the reflective layer for reflecting irradiation.

As set forth above, Applicants respectfully submit that the neither Antoniadis nor Kanou explicitly discloses that <u>a contact surface between the reflective layer and the first electrode is a rough surface so as to reduce color shift with a wide viewing angle</u>. Furthermore, Applicants respectfully submit that there is no teaching, suggestion, or motivation supporting the combination of Antoniadis and Kanou and the teaching of the functions and advantages of a top emission OLED with a contact surface between <u>the reflective layer and the first electrode being a rough surface so as to reduce color shift with a wide viewing angle</u>. Even if the reflection electrode of Kanou were combined with Antoniadis' OLED display, the electrode of Antoniadis would be substituted by the reflection electrode of Kanou with the function of reflecting lights, instead of using the reflective layer to reflect lights. Therefore, the rough contact surface between the reflective layer and the first electrode of the presently claimed invention is not equivalent to the convex/concave surface of Kanou's reflection electrode. Hence, the presently claimed invention is not obvious over Antoniadis and Kanou.

Applicants respectfully submit that the amended independent claim 1 further distinguish over the cited prior art references. Hence, claims 2-6, which respectively depend directly or indirectly on the allowable claim 1 and which include additional features, are also distinguished over the cited prior art references.

Claims 7-11 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Antoniadis in view of Cork (US2004/0070335) and Kanou. The rejection is respectfully traversed at least for the reasons provided below.

Regarding claim 7, the present invention provides a top emission organic light emitting display (OLED), comprising a substrate having a thin film transistor; a planarization layer disposed on the substrate covering the thin film transistor; a reflective layer disposed on the planarization layer; a first electrode disposed on the reflective layer and electrically coupled to the thin film transistor, a contact surface between the reflective layer and the first electrode being a rough surface so as to reduce color shift with a wide viewing angle; an organic layer disposed on the first electrode; and a transparent second electrode disposed on the organic layer; wherein, as a bias voltage is applied to the first electrode and the transparent second electrode, the organic layer emits radiation in all directions, the reflective layer reflects the radiation toward the transparent second electrode for increasing brightness of the top emission OLED.

Applicants respectfully submit again that the contact surface between the reflective layer and the first electrode being a rough surface so as to reduce color shift with a wide viewing angle is not supported by the combination of Antoniadis, Cork, and Kanou. Neither Antoniadis nor Kanou explicitly discloses that a contact surface between the reflective layer and the first electrode is a rough surface so as to reduce color shift with a wide viewing angle, as discussed above.

Furthermore, Applicants respectfully submit that there is no the teaching, suggestion, or motivation for supporting the combination of Antoniadis, Cork, and Kanou teaching the functions and advantages of a top emission OLED with a contact surface between the reflective layer and the first electrode being a rough surface so as to reduce color shift with a wide viewing angle. Even if the reflection electrode of Kanou were combined to Antoniadis' OLED display, the electrode of Antoniadis would be substituted by Kanou's reflection electrode to reflect lights, instead of using the reflective layer to reflect lights. Therefore, the present invention is not obvious over Antoniadis and Kanou.

Applicants respectfully submit that amended independent claim 7 distinguish over the cited prior art references, and claims 9-11, which respectively depend directly or indirectly on the allowable claim 7 and include additional features, as also distinguishable over the cited prior art references.

The requirements for establishing a *prima facie* case of obviousness, as detailed in MPEP § 2143 - 2143.03 (pages 2100-122 - 2100-136), are: first, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference to combine the teachings; second, there must be a reasonable expectation of success; and, finally, the prior art reference (or references when combined) must teach or suggest all of the claim limitations. As the cited prior art references, applied separately or combined, fail to teach, disclose or suggest all of the claimed limitations, and as there is no suggestion or motivation to combine various teachings of the cited prior art references to arrive at the presently claimed invention, the obviousness rejections are improper.

In view of the amendment and arguments set forth above, the Applicants respectfully submit that all pending claims 1-7 and 9-11 are in condition for allowance, and respectfully request the reconsideration and withdrawal of the rejections. Accordingly, a Notice of Allowance is respectfully requested. If a conference would expedite prosecution of the instant application, the Examiner is hereby invited to telephone the undersigned to arrange such a conference.

Respectfully submitted,

By: ______________________

Luan C. Do
Registration No. 38,434

NIXON PEABODY LLP
Suite 900
401 9th Street, N.W.
Washington, DC 20004-2128
Telephone: (202) 585-8000
Dated: November 21, 2005

High-Performance and Low-Power AMOLED Using White Emitter with Color-Filter Array

K. Mameno, R. Nishikawa, T. Omura, S. Matsumoto, S. A. Van Slyke*, A. D. Arnold*, T. K. Hatwar*, M. V. Hettel*, M. E. Miller*, M. J. Murdoch*, J. P. Spindler*

Sanyo Electric Co., Ltd., 180 Ohmori, Anpachi-cho, Anpachi-gun, Gifu 503-0195, Japan
*Eastman Kodak Company, Rochester, New York, USA

ABSTRACT

A couple of technologies for realizing a high-performance and low-power AMOLED using white emitter with color-filter array (WCFA) are presented. One is an RGBW pixel pattern, which can decrease the power consumption down to a half value in comparison with that of conventional RGB pixel pattern using the same white emitter and color filter method. The other is dimple interface (DI) technology, which can reduce a color shift with a wide viewing angle. These technologies are promising candidates for achieving high-performance AMOLED applicable to mobile applications.

INTRODUCTION

Full-color AMOLED displays were first demonstrated in 2000 [1] and commercialized in 2002 [2]. Others have also demonstrated full-color displays on both polycrystalline [3] and amorphous [4] silicon active matrix substrates in both top-emitting and bottom-emitting formats. All of these displays used precision shadow masking to define the red, green and blue emitters. Issues with scalability to large substrate sizes and high-resolution displays when applying shadow-masking techniques, however, have prompted the investigation of other methods to produce color. 15-inch WXGA and 2.5-inch QVGA AMOLEDs based on white emitter and color-filter array were demonstrated in 2002 to 2003 [5].

While technology for AMOLED has been improved dramatically, it still has some issues for being utilized to most of potential applications, which are lifetime, power consumption, and so on. Especially for mobile applications, low power consumption is strongly required.

RGBW AMLCD displays have recently been demonstrated [6] that are brighter than analogous RGB displays. Like the RGBW AMOLED, the unfiltered white emission leads to a higher display efficiency. In both the RGBW AMLCD and the RGBW AMOLED, the use of an additional white sub-pixel results in a reduction in the emissive area. In the RGBW AMLCD, this leads to lower red, green, and blue display luminance for a given backlight luminance and, consequently, a reduction in gamut because high-luminance saturated colors are lost. In the case of the RGBW AMOLED displays, no loss in gamut is incurred because the display luminance level is dependent on the current supplied to the sub-pixels.

An RGBW AMOLED display has been fabricated and compared directly to an RGB AMOLED of the same size [7]. For test images representative of images captured by digital still cameras, the RGBW display requires approximately 1/2 the power of the RGB display operated at the same luminance level.

On the other hand, an AMOLED has outstanding viewing-angle characteristics compared to an LCD, but the slight colors shift due to interference from its multiple layers [8].

For reducing the color shift, dimple interface technology has been developed to average out the interference [9]. In this technology, we can eliminate the intensified interference peak and reduce the changes in color and luminance by applying dimple interface to one or more layers in the TFT array.

As a result, we succeeded in developing AMOLED devices with no color shift even in case of large viewing angle.

RGBW PIXEL PATTERN

White OLED Structure

The white-emitting OLED layer structure is shown in Figure 1. Emission from blue and yellow zones within the multi-layer structure combines to provide a white emission that can be filtered appropriately to provide R, G, B and W emission from the display. Details of the fabrication of white OLEDs

RGB and RGBW Display Formats

RGB and RGBW displays with the same dot count were fabricated by adjusting the location of the sub-pixels, as shown in Figure 2. In both cases, the column count (data) was 528, the row count (scan) was 220 and the pixels were arranged in a stripe pattern. For the RGB display, the panel configuration was 176 (RGB) × 220 and the RGBW display was 132 (RGBW) × 220. For both configurations, the diagonal dimension was 2.16 inches. The display aspect ratio was 4:5, and images were displayed in both portrait and landscape orientations.

Characteristics of RGBW Display

The CIE chromaticity diagram with R, G, and B points achieved after filtration in this work is shown in Figure 3. Also shown are the white point of the unfiltered emitter (0.361, 0.380) and the D65 (0.3127, 0.3290) white point. Any color within each of the sub-triangles shown can be created by the appropriate combination of primary colors with the white.

Figure 4 shows the power consumption for the RGBW and RGB AMOLED displays for various images. On average, under identical luminance conditions, the power consumption required for the RGBW display is approximately ? the power consumption of the RGB display. For this image set, the RGBW and RGB average power consumptions are 180 mW and 340 mW, respectively. This is in agreement with modeling results based on 13,000 digital camera images and is indicative of the fact that saturated colors are relatively rare in most scenes. Clearly, images with large amounts of white content displayed using an RGBW format will require much less than ? the power of an RGB format, as a consequence of the highly efficient white channel, whereas scenes with large amounts of saturated color will be much closer in power consumption.

Figure 5 shows a side-by-side comparison of the RGBW and RGB displays. In the case of the

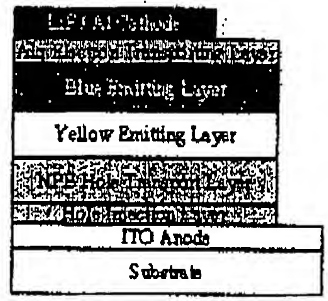

Figure 1. White OLED structure.

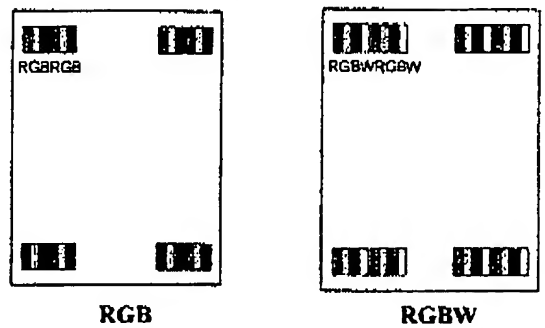

Figure 2. Display format for RGB and RGBW

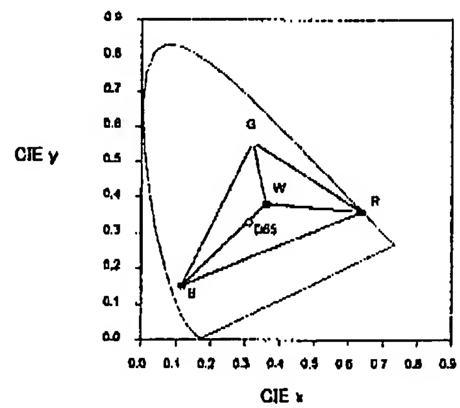

Figure 3. R, G, B and unfiltered W chromaticity

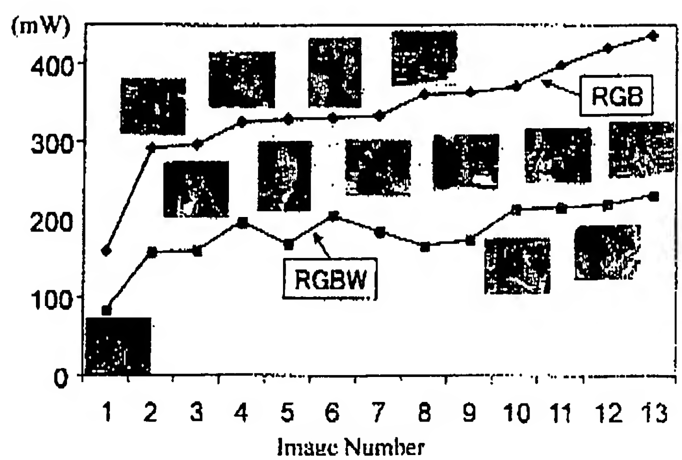

Figure 4. Power consumption of RGB and RGBW

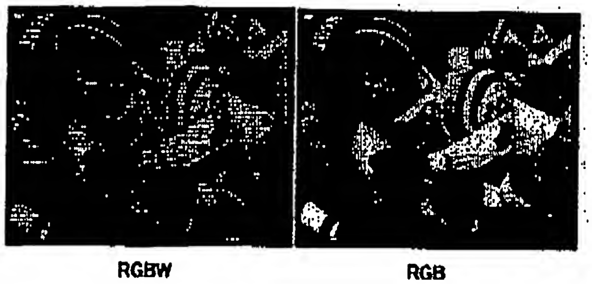

Figure 5. Images from RGBW and RGB displays

RGBW display, the lower resolution is clearly observed as horizontal lines, however, the luminance and gamut appears the same. It is expected that RGBW displays with the same number of pixels (25% more sub-pixels) will appear to be equal or higher in image quality than RGB displays.

DIMPLE INTERFACE TECHNOLOGY

Dimple Interface Structure

Figure 6 shows a TFT structure with dimple interface structure. In this structure, one layer is varied in thickness within each pixel. The thickness variations cause variations in the interference conditions and strong peak wavelengths. As a result, the total color emitted from the array is averaged and has no intensified peak.

Simulation of the Dimple Structure

A device with the dimple structure was simulated for the color blue by the Finite Difference Time Domain (FDTD) method [7]. In the simulation, we applied thickness variations to one layer below the anode. We varied the thickness of the layer from 0 to 13,000 nm.

Figure 7 shows the results of the simulation. "Blue Emitter" denotes the emission spectrum for the blue EL layer. Each spectrum has some interference peaks that depend on the thickness. In the case of the DI structure, the spectrum includes all spectra using the condition of various

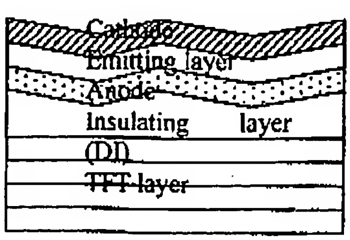

Figure 6. TFT structure with DI

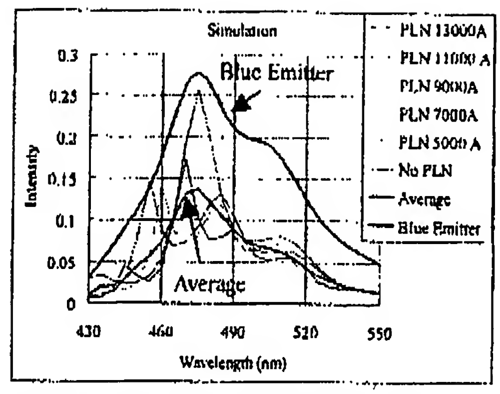

Figure 7. Simulation of blue spectra with DI

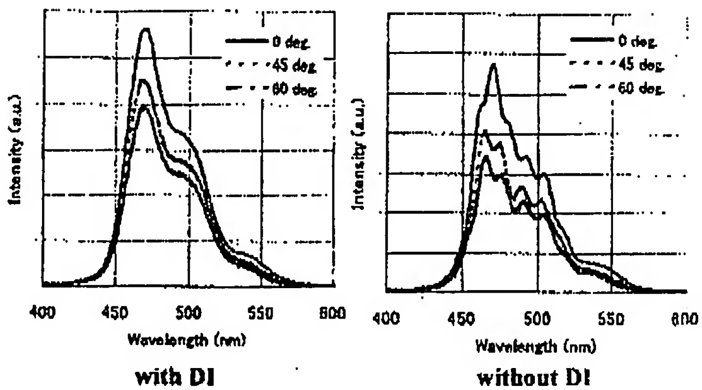

Figure 8. Blue spectra with and without DI

thicknesses. Therefore the spectrum with DI can be understood to be the averaged value. "Average" denotes the averaged value of the calculated spectrum for each layer thickness. It is clear that the "Average" is close to the emission spectrum. The result means that DI eliminates the intensified interference peak.

Actual Device Verification

We have developed a prototype AMOLED with DI. The dimple layer has a thickness variation of about 10,000 Å. Other layers, such as insulator, anode and emission layers, have the uniform thicknesses in the pixel.

In the AMOLED with DI, blue spectrum has peaks that originated from the blue emitter material and their wavelengths don't change so much according to the viewing angle as shown in Figure 8.

The range of the color shift from 0 to 70 degrees is shown in Table 1. Improvements are observed for all colors.

The color shift of white, which composed of red, green and blue, is also important. The white color depends on the relative luminance among red,

Table 1. The color shift from 0 to 70 degrees are shown about WCFA type OLED

	Red		Green		Blue	
	Δx	Δy	Δx	Δy	Δx	Δy
With Dimple	0.001	0.001	0.003	0.018	0.004	0.006
Conventional	0.003	0.004	0.005	0.018	0.004	0.007

Table 2. Relative luminance changes from 0 to 70 degrees are shown about WCFA type OLED

	LRed/Lgreen-1	LBlue/Lgreen-1
With Dimple	0.09	0.12
Conventional	0.09	0.20

green and blue as well as each color. The ratios of luminance values, (Lred/Lgreen-1) and (LBlue/Lgreen-1), are used as relative luminance values. The smaller the ratios are, the smaller the color shifts are. Their changes from 0 to 70 degrees are shown in Table 2. DI technology improves the ratio.

Figure 9 shows the color shift of white. White is arranged as Tc=6500K, duv=0 for the normal direction (0 degree). The white color shift of 'With DI' is smaller than that of the conventional interface structure. This result means that DI technology improves the color balance.

Figure 10 shows the actual AMOLED device with and the conventional one in the case of 0 degree (perpendicular direction) and 45 degrees. The conventional display changes reddish at 45 degree, but on the contrary display with DI does not change color so much. We thus succeeded in developing AMOLED devices with revolutionary viewing angles using DI technology.

It is note that the DI technology is applicable to any type of AMOLED, not only the white emitter with color-filter array but the RGB pixeletion, and also both bottom emitter and top emitter.

CONCLUSION

We demostrate RGBW pixel pattern AMOELD using white emitter with color-filter array and dimple interface techology. These technologies can maximize the performance of AMOLED.

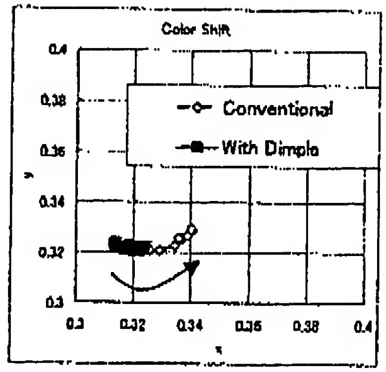

Figure 9. Color shifts of white are shown about the WCFA type OLED

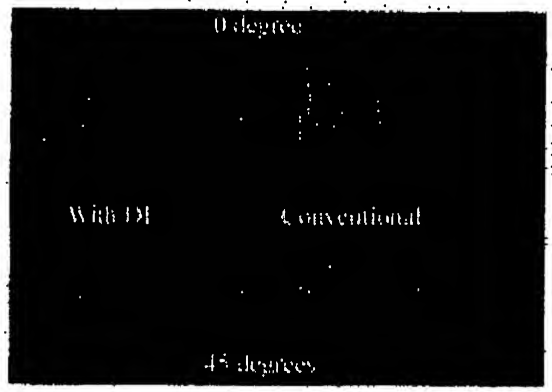

Figure 10. Actual WCFA type OLED display with DI and the conventional display (without DI) are shown in the case of 0 degree and 45 degrees

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